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An Overview of Colored Fundus Databases for Detecting Diabetic Retinopathy

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Abstract: *Every year a large number of diabetic patients suffer from mild-to-severe vision impairment or become blind because of diabetic retinopathy (DR). Early detection and timely treatment of DR can prevent vision impairment even blindness. However, the number of ophthalmologists in any country is not big enough to confirm regular check-up of each diabetic patient. Therefore, developing systems to detect DR automatically draw huge research interests. Researchers quite often use digital color fundus photographs in their research works. We survey 27 papers published in SJR ranked Q1 and Q2 journals to investigate which colored fundus databases are used in last 25 years.*

Key Word*: Retina, Diabetic retinopathy, Colored fundus photographs, Automatic diabetic retinopathy detection, Retinal Database.*

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I. Introduction

The retina is a thin, multilayered neural tissue that is mainly responsible for converting in coming light from an object into neural signals so that our brain can create an image of that object [1, 2, 3]. Any damage in the retina can cause mild-moderate-severe vision impairment, even blindness. Diabetic retinopathy (DR) is one of the five most common causes of vision impairment in adult [4, 5]. For many cases, it leads to irreversible complete vision loss, i.e., blindness [6]. According to the report in [5], DR was the cause of blindness for 1.07 million people among 7.79 billion blind people in 2020. Early detection and timely treatment of DR can prevent blindness. For that, all patients of diabetes need to go through repetitive annual retinal screening. Screening for DR is generally done through fundus examination by ophthalmologists or trained eye technicians using conventional mydriatic or non-mydriatic fundus cameras. It is a time-consuming process. The number of ophthalmologists or trained eye technicians is not enough to ensure this time-consuming process for all diabetes patients regularly, not only in a developing country but also in a developed country. With the advancement of computers, image processing techniques and tools, the research interest in automatically detecting DR using color fundus photographs has been increasing since the late 1990s. In this kind of research, databases of color fundus photographs play an important part. In this paper, we overview data sets of color fundus photographs used in 27 research works published from 1996 to 2020.

We organize this paper as follows. In Section 2, we briefly describe different issues regarding DR such as causes, symptoms, and levels of DR. In Section 3, we summarize our findings. Finally, we draw our conclusions in Section 4.

II. Diabetic Retinopathy

Diabetic retinopathy (DR) is a microvascular complication in which damage occurs to the retina's blood vessels of a diabetic patient. It does not have any noticeable symptoms until it is advanced. At the early stages of the DR, most of the patients do not experience any symptoms of DR, whereas few patients experience some come-and-go changes in their vision, such as trouble-some experiences while reading or seeing faraway objects. In later stages of the DR, the central retinal blood vessels (CRBVs), which are responsible for supplying blood to the inner retina, start to bleed into the vitreous, a gel-like fluid that fills our eye. Patients may see dark, floating spots or streaks that look like cobwebs. Sometimes, the spots vanish on their own without any treatment. However, the bleeding can happen again, get worse, or cause scarring without treatment for a long period. Gradually, untreated DR patients lose their eyesight completely.

Since patients of DR usually do not notice anything unusual in the early stages, most of the time, patients are unaware of this dangerous disease and remain untreated. However, by a thorough diabetic eye screening, DR can be diagnosed earlier. Therefore, every diabetic patient who is 12 years old or over is advised to go for a diabetic eye screening at least once a year or immediately after experiencing a worsening vision, sudden vision loss, blurred or patchy vision, floating shapes in the field of vision, eye pain or redness, or difficulty seeing in the dark.

There are mainly two levels in DR: non-proliferative DR (NPDR) and (2) proliferative DR (PDR). NPDR can be split into mild NPDR, moderate NPDR, and severe NPDR. Generally, hemorrhages of varying sizes, microaneurysms (MAs), hard exudates, soft exudates (cotton wool spots), intraretinal microvascular abnormalities (IRMAs), and venous looping or beading can be seen in the retina of an NPDR patient. New, very tiny, and fragile blood vessels can be seen in the retina of a PDR patient. Patients with moderate NPDR have a 12% - 27% risk of developing PDR within one year, whereas patients with severe NPDR have a 52% risk of developing PDR within one year. PDR patients are at a high risk of permanent vision loss.

III. Data Sets

We use the keyword ‘automatic diabetic retinopathy detection’ in the Google search engine to find previous studies. We consider only original studies written in English and published in SJR ranked Q1 and Q2 journals. Note that SJR (SCImago Journal Rank) is an indicator developed by SCImago from the widely known algorithm Google PageRank [7]. This indicator shows the journals’ visibility in the Scopus database from 1996. We also use the reference list of papers published in Q1/Q2 journals to find appropriate previous works. After finding a Q1 or Q2 journal paper, we investigate the databases used in that work.

We find 27 Q1/Q2 papers published from 1996 to 2020 which reported results on automatic DR detection using color fundus photographs. Our investigation based on these 27 papers found that 11 private data sets and nine publicly available data sets were used in the last 25 years. These data sets have images of different sizes as shown in Fig. 1.

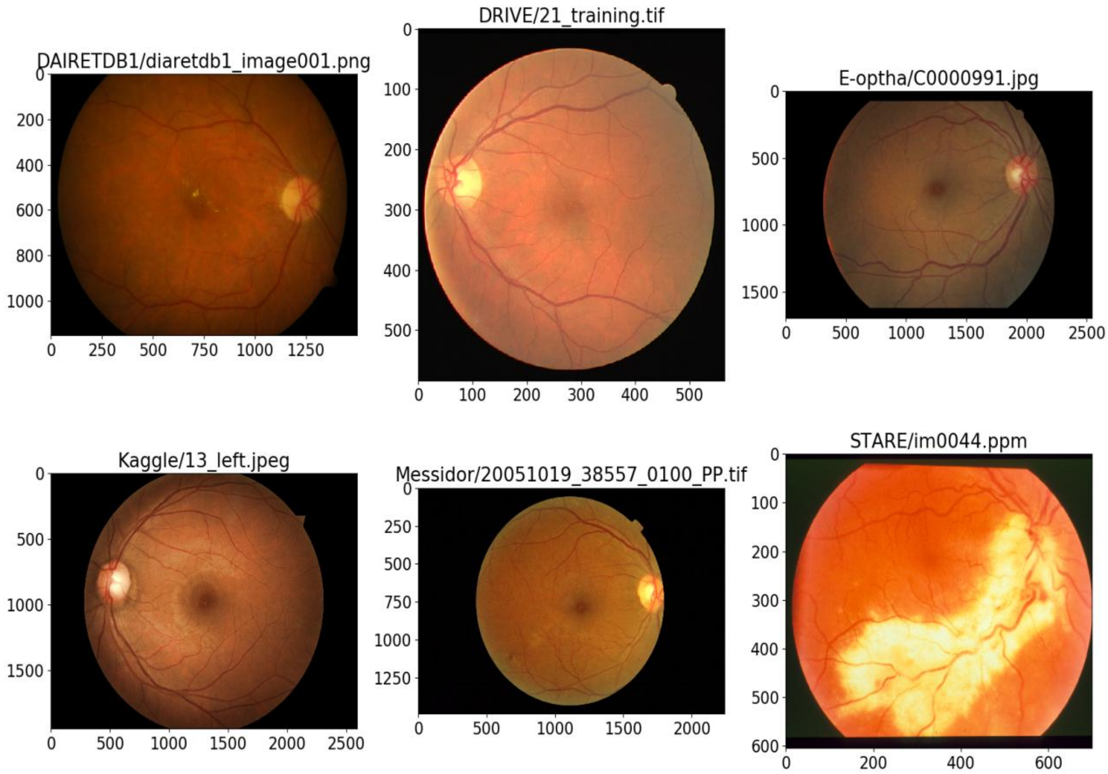

Figure 1: Some sample fundus photographs

The images of the private data sets are mainly collected from different hospitals and clinics. For more than 50% cases, the private sources are not revealed. See Table 1 for database-specific number of published papers, Table 2 and Table 3 for databases used in each previous research works, Table 4 for the elaboration of the names of publicly available data sets, and Table 5 for the revealed sources of private data sets.

Among these publicly available data sets, EyePACS is the largest data set with over 5 million retinal images. These images are collected from diverse populations using different kinds of fundus cameras. Research groups need to pay for most of the data of the EyePACS data set. A subset of the EyePACS is freely available for all research groups in the Kaggle platform. This subset is usually known as the Kaggle database for diabetic retinopathy detection or the Kaggle DR database. It contains 88,702 images, collected from 44,351 patients. One image was captured from each side of the retina. Therefore, there are two images per patient in the Kaggle DR database.

Messidor and Messidor-2 data sets are partly overlapped. 1,058 images out of 1,200 images of the Messidor data set were included in the Messidor-2 data set, which has 1,748 images. Similar to the Kaggle data set, this data set has two images per patient, one image per retina

Table 1: Database wise number of published papers reported results on automatic DR detection.

Database	Number of papers		
	Q1	Q2	Total
DIARETDB1	3	4	7
DRIVE	2	0	2
EyePACS	6	0	6
E-optha	3	2	5
FAZID	0	2	2
Kaggle DR	1	0	1
Messidor	3	2	5
Messidor-2	4	0	4
STARE	2	0	2

Table 2: Databases used in non-neural network based previous works for automatically detecting DR.

Year	Reference	Database
2000	Hipwell [8]	Private
2003	Wilkinson [9]	Private
2007	Gelman [10]	Private
2008	Abramoff [11]	Private
2009	Sopharak [12]	Private
2011	Fadzil [13]	Private
2013	Akram [14]	DIARETDB1, DRIVE, Messidor, STARE
2014	Akram [15]	DIARETDB1, DRIVE, Messidor, STARE
2015	Jaya [16]	Private
2016	Abramoff [17] Bhaskaranand [18]	Messidor-2 EyePACS
2017	Abbas [19]	DIARETDB1, FAZID, Messidor, Private
2018	Saha [20]	EyePACS
2020	Colomer [21]	DIARETDB1, E-optha

Table 3: Databases used in neural network based previous works for automatically detecting DR

Year	Reference	Database
1996	Gardner [22]	Private
2002	Sinthanayothin [23]	Private
2014	Ganesan [24]	Private
2016	Abramoff [17] Gulshan [25]	Messidor-2 EyePACS
2017	Abbas [19] Gargeya [26] Quellec [27]	DIARETDB1, FAZID, Messidor E-Ophtha, EyePACS, Messidor-2 DIARETDB1, E-Ophtha, Kaggle Diabetic Retinopathy
2018	Khojasteh [28] Lam [29]	DIARETDB1, E-Ophtha E-Ophtha, EyePACS
2019	Li [30] Zeng [31] Sahlsten[32]	Messidor-2 EyePACS Messidor

Table 4: Elaboration of names of public data sets used in automatic detection DR

Data Set	Elaboration
DIARETDB1	Standard Diabetic Retinopathy Database Calibration level1
DRIVE	Digital Retinal Images for Vessel Extraction
EyePACS	Eye Picture Archive Communication System
FAZID	Foveal Avascular Zone Image Database
Kaggle DR	Kaggle Diabetic Retinopathy
Messidor	Methods to Evaluate Segmentation and Indexing Techniques in the field of Retinal Ophthalmology
Messidor-2	Methods to Evaluate Segmentation and Indexing Techniques in the field of Retinal Ophthalmology 2 (Messidor + Extension)
STARE	Structured Analysis of the Retina

Table 5: Sources of Private Data

Reference	Data Source
Gardener [22]	Not revealed
Sinthanayothin [23]	Department of Medicine, St Thomas' Hospital, London, UK
Ganesan [24]	Department of Opthamology, Kasturba Medical College, Manipal, India
Jaya [16]	Not revealed
Fadzil [13]	Not revealed
Sopharak [12]	Eye Care Center, Thammasat University hospital, Thailand
Gelman [10]	Not revealed
Hipwel [8]	Diabetic clinic in Aberdeen, UK
Wilkinson [9]	Not revealed
Abramoff [11]	Not revealed

Table 6: Brief information of public data sets used in automatic DR detection. [**-**: not revealed]

Data Set	Height x Width	FOV	Fundus Camera	#Images
DIARETDB1	1500x1152	50^0	ZEISS FF450plus	89
DRIVE	584x565	45^0	Canon CR5-NM 3CCD	40
E-Ophtha	2048x1360, 2544x1696, 1440x 960, 1504x1000	-	Topcon TRC-NW6S Canon CR-DGi	463
FAZID	420x420	-	-	40
Kaggle DR	211x320, 289x433, 315x400, 533x800, 1184x1792, 1216x1600, 1444x1444, 1444x1620, 1536x2048, 1664x2496, 1666x2500, 1696x2544, 1880x2816, 1920x2560, 1944x2592, 1957x2196, 2000x3008, 2048x3072, 2056x2124, 2056x3088, 2136x3215, 2304x3456, 2336x3504, 2448x3264, 2560x1920, 2592x3872, 2592x3888, 2848x4272, 2848x4288, 3168x4752, 3264x4928, 3456x5184	-	-	88702
Messidor	960x1440, 1488x2240, 1536x2304	45^0	Topcon TRC-NW6	1200
Messidor-2	2240x1488	45^0	Topcon TRC-NW6	1748
STARE	605x700	35^0	-	400

IV. Conclusion

Diabetic retinopathy (DR) causes vision impairment for a large number of people every year in the whole world. In order to reduce the burden of ophthalmologists, automatically detecting DR is ongoing research. In this paper, we survey 27 research works published from 1996 to 2020 to investigate the data sets of color fundus photographs.

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